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THE VOLCANOES OF THE PACIFIC COAST OF THE UNITED STATES.

By S. F. EMMONS.

Earthquakes and volcanoes, from the earliest times, have been the natural phenomena which most excited wonder and awe in the human mind. To the primitive man they were the direct manifestations of the power and anger of an unseen and vindictive spirit. The earthquake, being visible only in the *results* of its destructive work, has not been clothed by his superstitious mind with the personal attributes assigned to its more tangible brother, the "burning mountain," which he regards as the abode of an unseen spirit, whose wrath at the misdoings of the human race, when it can no longer be restrained, manifests itself in fire and destruction to all the dwellers around. Even our half-civilized Indians of the Northwest, in spite of their association with the white man, cannot be induced, by hope of reward or fear of punishment, to approach the snow-covered peaks in their midst, whose actual manifestations of volcanic energy must exist in their minds as dim traditions; but which, nevertheless, they regard as the abode of an evil spirit, who will draw them down to certain destruction, if they come within his reach.

The incredulous spirit of modern science regards these manifestations of a hidden power with no less interest, but sees in them, instead of the personal spirit, a possible clue, which, by investigation, may lead to the discovery of the causes and manner of the formation of our earthly dwelling-place, and how it has become, from a mass of incandescent gas, as the generally-received nebular hypothesis would have us believe, the rigid mass of contorted, rocky strata, of infinitely varying composition, which constitutes the present surface of the globe. With his seismograph, the student of earthquake phonomena determines the direction, height, and breadth of the waves or movements of the earth's surface, which are manifested in earthquake-shaken countries, and hopes some day to establish a bureau from which earthquakes may be foretold, as "Old Probabilities" now tells us when to expect rain. Following the path of the earthquake through a mountain region he studies the work it has accomplished, throwing down a portion of a mountain here, building up another there, and reasons out the probable influence which such movements of the surface had in the original building up of our mountain systems.

In the volcano the geologist finds an even more direct and evident manifestation of nature's processes—an actual example of rock formation and mountain building; for, geologically speaking, all volcanoes, even those which have been quiet or extinct within historical times, are young and newly formed, and hence show in their structure a comparatively fresh and unaltered example of mountain architecture, and instances are not wanting of volcanoes having built themselves up in a very short time, as it were out of a level plain.

Humboldt first enunciated the great philosophic conception that the phenomena of volcanoes and earthquakes are an expression of the reaction of the earth's interior upon its exterior. After having visited the immense volcanoes of the Andes, he thought that to account for their great elevation it must be supposed that, at the time of their formation, the earth's crust had been lifted up in a dome shape by the force of the accumulated gases and molten rock beneath, which afterward poured forth from the summit of the dome where its crust was thinner and more easily pierced. This so-called crater-of-elevation theory, whose most prominent upholders were Humboldt and the scarcely less famous

Leopold von Buch, has, in more modern times, fallen into disrepute, and the present school of English geologists—the uniformitarian school, of which the late Sir Charles Lyell was the head—does not admit that there has been any elevatory or pushing-up force exercised by the lavas proceeding from a volcanic vent, but that the mountain is formed simply by the accumulation of successive flows, piled one above the other around the central orifice.

Mr. Poulett Scrope, who is, probably, the most eminent English volcanic geologist, and who has been the principal opposer of the crater-of-elevation theory, says that the steep angles of dip which are found in the stratified lavas of many volcanoes may be explained by the fact that the steepest, and, indeed, the majority of volcanic peaks are formed of trachytic lavas, which are light, crystalline and viscous, and were, probably, not in a completely molten condition at the time of their ejection; that for this reason, as well as on account of their property of cooling more rapidly, they might be piled up to a great height, without flowing out laterally to so great a distance as their angle of inclination might lead one to expect. That, on the other hand, the lava-flows which have extended to great distances at comparatively slight inclinations were of basaltic or basic lavas, which have a much greater fluidity in the molten condition, and from their physical characteristic (their cooler surface forming a non-conducting envelope) preserve their internal heat indefinitely.

The facts upon which Mr. Scrope has founded his theories have been gathered almost exclusively from the classic European localities, the extinct volcanoes of the Rhine and of Auvergne, the still active Mediterranean volcanoes of Vesuvius and Ætna, and their less important brethren Stromboli and Santorin, upon which an immense amount of scientific labor and careful investigation have been expended. It is easy to understand, therefore, of how great importance it is to geological science that careful and thorough investigations should be made in the volcanic regions of this country, where the same phenomena are presented on a far grander scale than in Europe, that it may be seen whether the rules, so rigorously laid down there, are confirmed by our facts.

A most important contribution to the science of volcanic rocks has already resulted from investigations made in the western United States. An eminent German geologist, Baron Ferd. von Richtofen, whom long study and experience in the volcanic regions of Europe had peculiarly fitted for the task, spent a number of years in California and Nevada, studying the infinite variety of volcanic rocks found there, and, in 1868, published under the auspices of the California Academy of Sciences, as the result of his labors, a memoir entitled "A Natural System of Volcanic Rocks." In this memoir he made the first attempt yet made of classifying the Tertiary volcanic rocks, which present so great differences of mineralogical composition and physical structure, according to their relative age. This classification, whose general correctness has been confirmed in the most remarkable manner by the investigations of Mr. Clarence King's Exploration of the 40th Parallel, was criticised in a most illiberal manner, and its results ridiculed by Mr. Scrope, who fancied that he discovered therein a possible admission of the partial correctness of the crater-of-elevation theory, which he prided himself upon having long ago most effectually demolished.

These few remarks are not intended as a preamble to any technical geological discussion, which might, perhaps, be hardly appropriate upon this occasion, and which the uncompleted condition of the exploration of which I am to speak would not authorize, but merely as a suggestion of the peculiar interest from a geological point of view, aside from the charms of discovery and adventure, which such expeditions present.

Volcanic rocks, in the broader sense of the word, are not confined to actual volcanoes. Rocks which, in respect to their mineralogical composition and physical character, are quite analogous to lavas, are found spread out over vast extents of country where no traces of volcanic craters are found. These are supposed to have come from so-called massive eruptions; that is, to have been poured out upon the surface in former geological periods from immense fissures in the earth. Such are the popularly-called "trap-rocks" of the Connecticut valley, and those which form the Palisades of the Hudson, which, however, antedate in age the principal outflows of volcanic rocks. The term is more strictly confined to those which were poured out during the Tertiary period—that epoch of the world's history which immediately preceded the appearance of man upon the earth. The actual volcanoes of the present day may be said to represent, in a general way, the last dying efforts of the great eruptive agencies of former times, concentrated into single isolated vents.

Within the United States the appearance of Tertiary volcanic rocks is mostly confined to the western portion, included in the great elevated region of the Rocky mountains; in the line of Territories bordering its western crest they cover a very great proportion, perhaps nearly half, of the surface. It is difficult to picture in one's mind the conditions of this region at the time of such intense exhibitions of volcanic energy. We know that then the Pacific ocean encroached upon the great valleys of California, and extended up to the very foot-hills of the Sierra Nevada, while, in the interior basins, were great fresh-water lakes or seas of ever-varying outlines; a much warmer climate than that of the present day prevailed, and possibly a tropical luxuriance of vegetation flourished.

From time to time this region must have been the scene of terrific exhibitions of volcanic phenomena, in comparison with which the catastrophes of modern times—even in those countries most subject to earthquake shocks and volcanic eruptions—would sink into comparative insignificance. We know that in some parts, notably in the upper basin of the Columbia and Snake rivers, tens of thousands of square miles were covered by continuous sheets of volcanic rocks, often many hundred feet in thickness. It is difficult to estimate the effects of these frequent outbursts upon the animal and vegetable life of this region; for, at the present day, in spite of occasional catastrophes, they find their most luxuriant development in volcanic regions; and though the animals and plants of those times are now largely replaced by different forms, and a desert exists where formerly was a garden, the chill influence of the long and destructive ages of cold of the Glacial period would sufficiently account for their extinction. As the massive eruptions of volcanic material gradually ceased, and the gaping fissures in the earth's surface healed and were covered over, we may imagine along the western coast of that time a line of volcanic vents like beacon-fires, lighting up the rocky headlands, from which issued almost continuous clouds of steam and sulphurous gases, accompanied by frequent showers of rocks and ashes and outflows of hot lava, which gradually built up around the orifices immense mountain-masses.

At what time these eruptions ceased we have no means of definitely determining. In the cold, white peaks of to-day, however, scored and carved as they are by glaciers, so that in many cases only traces of their former structure are left, the casual observer would scarcely suspect these ancient fiery mountains; and yet even now there slumbers within their mass a spark of the ancient fire, which may some day break forth into a conflagration. The volcanoes of the Pacific coast of the United States are included in that great volcanic belt, the "Ring of Fire," which surrounds the Pacific ocean, and which throughout the greater part of its extent presents actually active volcanoes. Those of our country are in the dormant or quiescent condition, or, as is the general term, are extinct. There are, it is true, traditions in regard to some of them of eruptions within the present century; but allowance must be made for the vividness of the mountaineer's imagination, since examination shows that they must have been of very slight importance, probably only showers of ashes. It is not impossible that they may some day become active, but the approach of this condition will be sufficiently heralded by the floods which will proceed from the melting of their snow-coverings.

In the map which I have prepared it has been endeavored to present the physical structure of the region of these volcanic phenomena in such relief as to be readily understood. It represents an extent of coast-line north and south, of about nine hundred miles, corresponding in latitude to our eastern coast-line, from the Carolinas north to the Gulf of St. Lawrence, and includes the greater part of the States of California and Nevada, with all of Oregon, Washington, Territory, and a narrow strip of Idaho. The line of mountains parallel to the coast which stretches from one extremity of the map to the other, is that of the Sierra Nevada and the Cascade mountains, which forms the western border of the great elevated mountain region included in the Cordilleran or Rocky mountain system. The Sierra Nevada rises in long, gentle slopes, for fifty miles, from the great California plains on the west, and presents an abrupt mountain wall over-looking the elevated desert valleys of the interior or Nevada basin on the east. From its culminating points in the region of Mount Whitney, at the southern extremity of the map, which reach an elevation of nearly 15,000 feet, its crest falls off slightly to the north, and where crossed by the railroad its peaks are about 9,000, and its passes 7,000 feet above sea-level. In the northern portion of California its continuity is broken, and from Lassen's Peak northward, for nearly 100 miles, it is no longer visible as a continuous chain, but is replaced by broken ridges and isolated volcanic peaks, standing interspaced, with comparative regularity, in the direct line of the Sierra. These peaks rise above the snow-line, and form nature's monuments to mark the boundary line between the interior plains and the coast-region. The geological continuation of the Sierra Nevada, as far as our limited knowledge of the geology of that region permits us to determine, would seem to be formed by the comparatively unknown chain of the Blue mountains, which trends off to the northeast through eastern Oregon.

In northern Oregon and Washington Territory the Cascade mountains occupy a corresponding topographical position with the Sierra Nevada, but are of more recent geological formation, and present a less distinctly defined crest, rising to heights of only 4,000 to 7,000 feet above sea-level. Notwithstanding their inferior elevation, they seem to mark even more sharply than the latter the climatic boundary line between coast and interior basin-regions, or that of frequent rains, and of almost perfect aridity during two-thirds of the year. Owing to the greater rainfall in these. more northern regions, as well as their difference of latitude, the immense pine forests which clothe only a portion of the Sierra spurs, here extend from the summit down, through the very valley-bottoms, growing with an almost tropical luxuriance, and forming a very serious obstacle to exploration. Along the crests of the Cascade mountains extends the line of volcanic cones, here rendered more impressive by the contrast of their greater accumulation of snow with the forest-covered mountain-ridges below.

The coast-line throughout this extent of country is marked also by a series of mountain-ridges, in general of inferior elevation and more irregular structure, known as the Coast ranges. Between them and the Sierra Nevada lie the long valley-plains of the St. Joaquin and Sacramento rivers, forming a trough-like depression, to which, in Washington Territory, corresponds the partially submerged valley of Puget's Sound, bounded on the west by the almost unexplored Olympus mountains. The more prominent of the volcanic cones represented here are Lassen's Peak and Mount Shasta, in northern California; Mount Pitt, the Three Sisters, Mount Jefferson and Mount Hood, in Oregon; and Mounts St. Helens, Adams, Rainier and Baker, in Washington Territory.

Along the Sierra Nevada proper, which was lifted above the sea long before Tertiary times, volcanic activity has been rather locally confined to a few small volcanic vents along its eastern base, near Mono lake, and to flows of basaltic lava on its western slopes, which have, in many instances, covered the gold-bearing gravels of the late Tertiary times.

Mono lake is a picturesque little sheet of water, about fourteen miles in its longest diameter, lying nestled at the eastern foot of the Sierra Nevada, about opposite the far-famed Yosemite valley. These mountains form a precipitous granite wall, some 8,000 or 9,000 feet in height on its western shores; while to the eastward extend the flat sage-brush deserts characteristic of the great basin of Nevada. Its waters are very dense and rich in mineral salts, so dense that the body floats upon its surface like a cork, while the salts which it holds in solution—principally soda and borax—render it peculiarly cleansing, so that the barbers of the neighboring mining town of Aurora use it as a natural "shampoo-water." In the midst of the lake is a small island, which contains a crater and which abounds in hot springs; to the presence of the latter, which, doubtless, also exist below the surface of the lake, is due the peculiar fact that the surface-waters of the lake are quite warm to a depth of a few inches, while the deeper parts are icy cold, since the lake is mainly fed by the melting of the Sierra snows.

To the south of the lake extends a line of volcanic craters, forming a low ridge, which are relatively unimportant in height by the side of the towering peaks of the Sierras—their highest peak rises only about 2,700 feet above the valleys—but which are extremely remarkable for the rock of which they are formed, a black glass, like bottle-glass, known to the geologists under the name of obsidian. This is the only region in which this rock, so much prized by the Indians for making their arrow-heads, is known to occur in any considerable quantity, and yet small fragments may be found in almost any part of the Rocky Mountain region, often hundreds of miles distant. The craters are generally surrounded by a "cinder-cone," or circular, rampart-like ridge of loose scoriæ and volcanic ash, within which are piled up irregular masses of black and grey glass and white frothy pumice, the latter so light as to float on water, and often drawn out in silky threads, like spun glass.

Lassen's Peak is the southernmost of the chain of volcanic peaks represented on our map, and forms, as it were, the northern extremity of the Sierra Nevada crest. To the technical geologist it is, perhaps, the most interesting of all those I have mentioned; it was in its study that Von Richtofen gathered the most important facts which led to his classification of the relative ages of volcanic rocks. Here are found traces of long-continued volcanic activity, remnants of ancient craters formed and destroyed ages ago. To the original andesitic eruptions have succeeded those of trachyte and rhyolite; the latter in the remarkable granitic form knows as Nevadite, the masses of which, in cooling, have shrunk and split up in the most remarkable manner, resulting in a confused region of riven rock-masses, to which the appropriate name of Chaos has been given. The final flows have been of basalt, which rock has covered such immense extents of country to the north and east. Indications of the internal heat still remaining, at no great depth beneath the surface, are found in its solfataras and hot springs, from which there is a constant escape of sulphurous gases and steam; these are concentrated in the basin of an old crater, christened in the characteristic Californian vernacular, Bummer's Hell. Here, also, are found the so-called "mud volcanoes;" little conical mounds only a few feet in height, with a central orifice, from which from time to time are thrown out masses of soft, wet mud; within them a constant rumbling, like subdued thunder, may be heard at all times; and, by plugging up the orifice, an artificial eruption may, after a short interval, be produced, and the plug will be thrown out with great force. The scenery around Lassen's Peak is wild and savage; but as the cone itself rises only about 2,000 feet above the surrounding country, attaining an altitude of 10,000 feet above sea-level, and is, moreover, out of the line of travel, it does not afford to the general tourist the attraction found in the loftier peaks to the north.

Mount Shasta, one of the grandest as well as the most accessible of our great mountain-peaks, stands comparatively isolated, being surrounded by low ridges on the east, and on the west by a broad, open, treeless valley, through which runs the projected line of the California and Oregon Railroad. Its summit, which has been carefully measured by the barometer, reaches a height of 14,440 feet above sea-level, so that from this valley, whose elevation is between 2,000 and 3,000 feet, may be seen nearly 12,000 feet of mountain rising before one. Its ascent, which, though laborious, is by no means dangerous, will doubtless, at no distant day, be included, with the visit to the Yosemite valley, in the list of things to be "done" by the tourist who visits the Pacific coast.

By the kindness of my friend, Mr. Gilbert Munger, the well-known artist, I have been able to present this evening characteristic sketches of the three principal peaks of which I am to speak, copied from studies made by him on the spot. The view of Shasta is taken from a point about thirty miles to the northward of the peak; the shoulder that we see on the west of the summit is a beautiful crater of almost perfect circular form, nearly a mile in diameter, whose rim is about 2,000 feet lower than the main summit, while its interior is about a thousand deep, and contains another central cone, formed, like the rim, of broken lava-masses, and rising to an equal height. The rim of the crater is a mere knife-edge of rock, so narrow that at the time of our exploration, when we passed a night on it, it was found necessary to break away the rock with our hammers in order to make a place wide enough to sleep on. On the highest point of this rim, the lava-masses are perforated by curious holes like worm-holes, which are lined with green glass, the result of the melting of the rock by lightning, for which this point seems to present great attraction. It has, consequently, received the name fulgurite, which was given by Abich, a German geologist, who first observed this phenomenon in the mountains of the Caucasus.

The main summit consists of two peaks separated by a little valley or gorge about 100 feet deep, in which is a hot spring, still sending out steam and sulphurous gases. It would appear to be a portion remaining of a much older cone, whose outlines are now almost irrecognizable. Another attraction of the peak are the still active glaciers, which are found on its northern slopes, and which, though of less imposing dimensions than those of the more northern peaks, are much more accessible, and remarkable as being the first that had been found, at the time of their discovery, within the United States. Along the western slopes of the peak are the remains of hundreds of little volcanic cones, stretching out into the valley. A larger one to the southwest, known as Little Shasta, presents in outline a remarkable resemblance to the larger peak, a miniature reproduction, as one might say, though it is nearly equal in height to Vesuvius, rising more than 3,000 feet, and far steeper and more difficult to ascend.

About 60 miles north of Shasta, in southern Oregon, is Mt. Pitt, a volcanic peak, presenting a beautifully regular outline as seen from Jacksonville, on the west. Its height is less than 10,000 feet, yet its upper portion is snow-covered during the greater portion of the year. Its exploration was undertaken by Mr. A. B. Emmons in the summer of 1875, but his report, which will doubtless give many interesting details of its formation, has not yet been published. It shows, also, the traces of a crater-structure, broken down on the northeast side; its lavas, though having a general resemblance to the trachytes of Shasta, present some interesting peculiarities of composition, which render their classification somewhat difficult, and their determination can only be satisfactorily made by the aid of the microscope.

Throughout the region to the northeast of Shasta, in eastern Oregon and northwestern Nevada, are immense extents of country covered by flows of basaltic rock. Such flows are characterized by a peculiar topography. Broad stretches of table-topped ridges are cut through in every direction by an intricate network of narrow gorges and ravines with perpendicular sides, abounding in natural fortresses and caves, and traversed by streams which frequently disappear for distances of many miles beneath the horizontal beds of basalt, to reappear in a most unexpected manner, and which are generally designated by the name "Lost River." It was in such "lava-beds," as the popular term is, in a region near the boundary of California and Oregon, that during the late Modoc war a mere handful of Indians were able, by their intimate knowledge of the intricacies of the region, to hold at bay, during several months, the whole military force that could be brought against them.

East of Mt. Pitt are numerous lakes, some of very considerable extent, which are probably fed largely from springs issuing from the volcanic rocks. Most interesting among these is Crater lake, lying east of north from Mt. Pitt, which fills an ancient crater about eight miles in diameter. Its walls rise but little above the surrounding country, but are from 500 to 1,500 feet above the level of the lake, and so precipitous that it is difficult to reach the shores without the aid of ropes. The showers of ashes which once issued from this crater can easily be traced by the peculiar character of the soil, for a distance of about 28 miles east and 10 west of the lake. North of Mt. Pitt, in the line of the Cascade mountains, are the volcanic peaks of the Three Sisters and Mt. Jefferson, little known and of relatively less importance, but rising above the snow-level, and forming a beautiful feature in the scenery of Oregon by the brilliant contrast of their delicate white forms with the sombre green of the pine-clad hills below.

In the region of the Columbia river, which presents some of the grandest and most picturesque scenery of the United States, the volcanic phenomena both of massive eruptions and of crater-cones, which here attain an enormous development, can be seen under most favorable circumstances.. This river, which drains an area of nearly 200,000 square miles in the interior basin of the Rocky mountains, has cut its channel, in a cañon-like gorge, transversely through the Cascade mountains almost down to the level of the sea. By means of the section, thus exposed, we are enabled to study the structure of this mountain range to its very core, and are not, as is usually the case, obliged to content ourselves with reasoning it out by inference from the rocks which form its surface.

At the Cascades nearly in the middle of the range, which form the limit of navigation from the ocean, and to which point the work of the Coast Survey has been carried, so as to furnish trustworthy measurements, the basaltic cliffs rise 3,700 feet, nearly perpendicularly, above the river. A thickness then of over 3,000 feet of lava has been accumulated from massive eruptions to form the range at this point. At the base of the cliffs is found a conglomerate or pudding-stone—a rock made up of rounded pebbles and gravel, which time and pressure have compacted and hardened, and which here indicates a former shore-line which has been covered by the basalt. Within the conglomerate are found trunks of trees, some changed to stone, some merely carbonized, with leaf remains, which enable us to determine the geological age of the period immediately preceding the building up of the range at this point. This was the

Miocene Tertiary, a time when a tropical climate prevailed over our whole continent, even far up into the Arctic regions.

This bed of conglomerate also gives a clue to the history of a more recent period, to a change in the course of the river and the formation of the Cascades themselves. The Cascades are rather rapids than falls, where the river descends rapidly for a mile or two, in one place foaming and boiling over masses of broken rock in its bed. They form, as already stated, the head of navigation to vessels coming from below, and a short railroad, some six miles in length, on the northern bank, conveys passengers from the steamer which comes from Portland to that which runs to the Dalles from the head of the Cascades. Just beyond this railroad may still be distinguished in the forests which cover the bottom of the cañon—here considerably wider than the bed of the river—the traces of an ancient stream-bed, somewhat higher than the present one, but which, at no very distant period, was evidently occupied by the river, being more in its direct course than the bed it now occupies at the Cascades. Indians tell us that there was once a natural bridge at the Cascades, by which their ancestors used to cross the river, and this is rendered probable by the existence of flat, table-like masses of basalt on either side, which might have formed the piers to such a bridge. Again, along the shores of the river, above the Cascades, are great numbers of dead tree-trunks, standing in the water and partially submerged even at its lowest stages. Pine trees would not have grown to such size in the water, or even if they had, what should have killed them all so uniformly? The explanation seems simple enough when all these facts are combined. At the time when, in the course of cutting this cañon through the mountains, the river had reached nearly its present level, but was still running in the old stream-bed, its waters found a new outlet by perforating this permeable stratum of conglomerate. The opening thus made grew rapidly larger, owing to the easy disintegration of the conglomerate, until it was large enough to take the whole stream; and this bed being at a depth much lower than the present, the old stream-bed was abandoned, and along the upper side of the river the trees grew down to its very edge, while the river, for a short distance, had the character of the lost rivers of which I have already spoken, being concealed beneath the basalt bridge; but in course of time the supports of the bridge were undermined and the whole mass of overhanging basalt fell into the stream, damming it up so as to produce the present Cascades, and causing a rise or "backing-up" of the water in the upper part of the stream, so that the trees along the edge, having the soil washed away from their roots by the rising water, gradually died and decayed, leaving only the stumps we now see lining the borders of the river.

Mt. Hood, which has the most graceful outline of all these volcanic peaks, rises out of the very crest of the Cascade mountains, about 25 miles south of the Columbia river. The view which you see is taken from the mouth of the Hood river, a stream which rises among the glaciers of its northern slopes, and flows northward through a region densely covered with pine forests to the Columbia river, which it joins about midway between the Cascades and the Dalles.

When the English explorer Vancouver, who gave to this peak its name, first saw it from his ships as he sailed up the majestic Columbia, he estimated its altitude to be at least 25,000 feet, and thought it probably the highest mountain in the world. Col. Williamson, of the Coast Survey, made the first barometrical, and consequently the first trustworthy, measurement of this peak, and his determination has been confirmed by that of Mr. Arnold Hague, of our party, made during his explorations in 1870. By these stricter rules it has fallen from 25,000 to 11,225 feet, but still remains, in the opinion of admirers of mountains, one of the most beautiful peaks in the world. It, also, is only a portion of the rim of an ancient crater, and its summit consists of a single block of lava only a few feet square, from which one may look down, almost perpendicularly, for thousands of feet on the north, and in other directions at a dizzy angle. Its ascent is made from the east, along the left-hand edge, and is sufficiently trying to one whose nerves have not the steadiness required to look without flinching over the brink of precipices, when standing on a rock scarcely large enough for one foot to rest upon. In the shelter of the peak on the north side, where the walls circle round what was once a crater, clouds frequently collect, even on an almost cloudless day, and from time to time rise above the peak, giving it the appearance of smoking. So deceptive is this appearance, that frequent reports are brought in of an eruption on this peak, whereas its examination by Mr. Hague showed that no eruption can have taken place within a very long time—certainly not within the memory of man.

In Washington Territory, to the north of the Columbia river, in about the same latitude, rise two other volcanic peaks, one to the east, the other to the west of the summit of the Cascade mountains—Mt. Adams and Mt. St. Helens. Neither of these have been explored, or, so far as I know, measured, though their altitude is probably near 10,000 feet.

Mt. Adams, as seen from the east, presents a broad, flat summit, and if it has a crater, it must be of very considerable dimensions.

Mt. St. Helens, on the other hand, is remarkable for its regular conical shape, and being, probably, easy of ascent, it would seem strange that it has never been ascended, since it is scarcely more than 20 miles from well-traveled roads, were it not for the almost impenetrable character of the forests of Washington Territory on the west slope of the Cascade mountains. It is, however, the only peak of which I was able to get a definite account of an eruption. I was told by an old French Canadian voyageur, formerly in the employ of the Hudson's Bay Fur Company, that St. Helens was in active eruption in the winter of 1841–2. To use his expression, the light from the burning volcano was so intense that one could see to pick up a pin in the grass at midnight near his cabin, which is some 20 miles distant in a straight line. I myself could distinguish with my glass the apparent track of a lava-flow which had cut its way through many miles of the forest that clothed its flanks.

The most imposing of all these great peaks, however, are those which are seen from the waters of Puget Sound—Mt. Baker and Mt. Rainier. The former, though only a little over 10,000 feet in height, is much nearer the sea, and, from its more northerly position, has a proportionately greater snow-mass. It has been ascended by an Englishman named Coleman, who published an account of this trip in *Harper's Monthly*, in which, however, little accurate description is given.

Mt. Rainier, or, as the Indians call it, Techoma, "The Great Snow," whose height is 14,444 feet, as determined by the triangulation of Col. Davidson of the Coast Survey, is, doubtless, the grandest single peak in the United States, including Alaska, and probably few mountains in the world surpass it in grandeur. The sketch which you see is taken from Steilacoom prairie, a low plain stretching eastward from the southern end of Puget sound—the term "prairie" in Washington Territory being applied to any natural clearing or space bare of trees. The point of view is distant about 40 miles from the base of the mountain; between is a dense forest-covered region, gently rising in low broad ridges towards its base, but so fore-shortened that the white snow-mass that towers above it seems within a pleasant day's walk. Here the crest of the Cascade mountains, which lies some 20 miles eastward of Rainier, is hidden by it. The peak itself has three summits, all of which are visible from this point. Of these the eastern is a small crater, while the other two are merely remnants of the walls of a former immense crater, whose restoration would, probably, nearly double the present size of the mountain. Nearer and more exact views of this mountain it has been impossible to obtain, and not to weary you farther with mere verbal descriptions, I shall venture to close the evening's talk with a brief narration of exploration, premising it with a mention of those which preceded my own.

In the year 1857, Lieut. A. V. Kautz (now a Colonel and Brevet Brig. General in the U. S. Army), who was stationed at Fort Steilacoom, on Puget's sound, undertook to make the ascent of Mt. Rainier. His party, which consisted of himself, one army surgeon, two private soldiers and an Indian guide, started from the Mishawl river, a day's ride from the fort, on the 9th of July. They traveled on foot, and after incredible difficulties and hardships reached the base of the mountain on the edge of the Nisqually glacier, at the end of the sixth day's march. On the seventh day they attempted the ascent of the southern peak. As their view was much obstructed by clouds, which overhung and at times surrounded them, the account which they gave is itself somewhat misty, and it is difficult to determine to what height they succeeded in reaching. At a quarter to six in the afternoon they attained a point they thought might be one of the summits, but they could perceive others still higher. As they reached their camp in a descent of three hours—accompanied, it is true, by glissades on the snow, in which one of the soldiers was badly hurt—it seems probable that it may have been merely a prominent point of one of the southern spurs. They found themselves much used up by their continuous hard climbing, and having run short of provisions, did not make another attempt, but returned with all possible speed to their starting point, which they reached on the twelfth day. The account furnished me by General Kautz gives a doleful description of their sufferings during the trip, and the results thereof to the various members of the party have a truly melodramatic flavor. Kautz himself lost his hat and fourteen pounds of flesh, and did not recover for many weeks. The doctor lost twenty pounds, was subject to violent pains in the stomach, and did not recover for three months. The Indian guide had an attack of gastritis and narrowly escaped with his life, while the two soldiers were in the hospital during the remainder of their term of service.

It was from the accounts which Lieut. Kautz brought back that Dr. Geo. Gibbs, geologist to the Pacific Railroad Expedition under General I. I. Stevens, probably derived the information which led him to announce the occurrence of granite as a dyke in recent lavas, proving this rock, hitherto considered of ancient origin, to be of very recent formation. Unfortunately for the success of this demolition of previously conceived geological theories, the facts on which it is founded were not correctly read by Lieut. Kautz. There is, indeed, at the foot of the Nisqually glacier, a mass of granite which, as seen in the cliffs on either side, seems to project up into the beds of trachyte which have flowed down from the volcano. It is not, however, a more recent dyke, but a pre-existing ridge of granite, which, having been covered by the flows of lava, has since been exposed and cut through by the glacial ice, which has channeled the slopes of the peak to a depth of several thousand feet.

From that time until the year 1870, I have no definite knowledge of any attempts to reach Mount Rainier, though I can but believe, from its prominence and apparent proximity, that some enterprising persons have been tempted to explore its slopes. That no account of any such has been published, seems to be sufficient proof that they were unsuccessful.

In the month of August of this year, Messrs. Stevens and Van Trump, of Olympia, W. T., who had long been contemplating an assault upon the snowy giant which is so beautifully seen from that picturesque town, made an excursion through the forest to its foot, and after many hardships succeeded on the 17th of August, 1870, in reaching its summit. Their trip has been graphically described by General Stevens in an article in the *Atlantic Monthly* for November last, and I shall not, therefore, repeat what he has already so well said with regard to the incidents of the trip. They unfortunately under-estimated the difficulties of the ascent, and reaching the summit only at nightfall, were obliged to pass a night there, for which they were entirely unprepared, and which might have had serious consequences for them had they not found jets of steam issuing from the crater, by which they were enabled to keep themselves warm during the cold midnight hours. Mr. Van Trump met with an accident on their descent, from the effects of which he was laid up for several months. As they were only two days at the actual base of the mountain, they necessarily saw but one side of it, and the description given by General Stevens of the northeastern side, must have been derived from other sources than his own observation.

It was in the latter part of the summer of 1870, that the geological party under the charge of Mr. Clarence King, of which I am a member, commenced a survey of the volcanic peaks already mentioned, with the view of presenting to the public accurate and detailed maps of each, and a geological monograph on their structure and petrological characteristics. Owing to the lateness of the season, the work of that year among the northern peaks scarcely amounted to more than a preliminary reconnoissance, and from causes beyond our control the plan has never been carried to completion.

On the 14th of September, having just spent five days with Mr. King on Mount Shasta, exploring its northern slopes and passing a night on either of its summits, it was decided that I should immediately commence a survey of Mount Rainier, lest in that more northern region the autumn rains and snows should drive us away ere our work could be accomplished. Mr. King proposed to join me himself as soon as his survey of Shasta should be completed; but, as it proved in the end, this work took so much more time than he had anticipated, that he did not make the attempt. We then were unaware that any attempts even had been made to reach its summit, and its exploration presented all the charms of an utterly unknown region.

Three hours after the decision was made I was driving rapidly to Yreka, some forty miles distant, where I took the stage, and after three days and nights of jolting over mountain roads, of whose roughness an eastern traveler can form but a faint conception, arrived at Portland to learn that Messrs. Stevens and Van Trump had only a few weeks before succeeded in reaching the summit of Rainier. In spite of this fact, it was the general opinion of the inhabitants that the attempt to take in a pack-train, which our baggage and instruments would require, and especially at this late season, was very dangerous if not utterly impracticable. Two days were now spent in a journey to the Dalles, to secure the co-operation of Mr. A. D. Wilson, who, as topographer, had been spending several weeks with Mr. Arnold Hague on the survey of Mount Hood.

A third day sufficed to get together the necessary provisions, and we embarked at daylight of the fourth on a steamer for Kalama, whence we reached Olympia, at the southern end of Puget sound, after a ride of three days, during which we never succeeded in catching a glimpse of Mount Rainier, owing to the rain-clouds which overhung us. At Olympia General Stevens kindly gave us all the information he could to facilitate our reaching the mountain, but, as it afterwards proved, the route followed by him on foot was not passable for mules. From here, a charming ride of twenty-five miles through alternate groves of pine and oak and open glades, brought us to Yelm prairie, where we found Mr. Longmire, the settler who had guided the Stevens party through the forest. He was the only person we could hear of who really had crossed the range at this point, the so-called mountaineers in this region being notoriously untrustworthy; and though many offered their services, claiming to have been at the base of the peak, close questioning easily proved that they were "romancing." Longmire belonged to the best type of western settlers, and the impression gathered from our conversation with him, that he was a thoroughly honest, energetic man, having, withal, an extremely modest estimate of his own abilities, was more than confirmed on a closer acquaintance. It was only with extreme difficulty that we succeeded in persuading him to accompany us, as he was firm in the opinion that it was too late in the season to undertake the trip with safety, and the opposition of his wife, who averred that the fatigues had more effect upon him than a month's sickness, was even more pronounced. I really believe that it was only a feeling of duty for the advancement of science, and a personal regard for us, fearing that some misfortune might befall us should we undertake the trip alone, as we most certainly should have done, that finally decided him.

It was about noon on the 27th of September that we finally started on our exploration; a party of four men with five animals, for we left the bulk of our provisions and mules to be brought along by Mr. King when we should have broken the way. Realizing, though perhaps not to its full extent, the difficulties of getting loaded mules through the tangled forest, we had reduced our baggage to absolute necessities, and allowed ourselves only two pack-mules to carry our instruments, provisions and blankets, while Longmire and I were to take "turn-about" in riding the old white bell-mare, who was to guide and watch over our loose mules. In availing ourselves of this privilege, as her stumbling qualities became more apparent, a most courteous reluctance characterized us both. In our first day's march, by the accidental breaking of one of our cistern barometers, it was found necessary to send back our one camp-man, and our party was thus still further reduced to three men with four animals. Just as we were about to plunge into the forest, the clouds, which had overshadowed us for four days previous, lifted for a moment, and gave us our first view of the magnificent peak we were about to attack; and a most rare sight it was! The dazzling whiteness of its snowy mass, brought out in stronger relief by the few black specks of bare rock peering through here and there, brought it so near that it seemed to rest upon the tops of the forest trees in front of us.

Our first few miles in the forest were exhilarating in the extreme, for our work for the last three years had been among the desert-plains and almost treeless mountains of the great interior basin of the Rocky mountains, while here we passed through endless aisles of stately pines, cedars and firs, whose size increased as we progressed, until trees of 200 and 300 feet in height, and 20 to 30 feet in circumference, became the rule rather than the exception. Animal life in the interior of the forest seemed not very abundant, so that the solemn silence, scarcely broken by the dim rustling of the wind on the distant summits of the trees, and the semi-twilight which the density of the foliage overhead produced, at first quietly refreshing, became ere long gloomy and oppressive.

During the first day's march we crossed the Nisqually river, whose milky waters plainly indicated its glacial origin, and made an early camp on Mishawl prairie, a little opening in the forest to the north of this river; for, in spite of the luxuriant vegetation of the forest, grass was very difficult to find, and our camping-places had to be chosen with especial reference to this very necessary plant. During the following days the passage through the forest, obstructed by fallen trees and tangled undergrowth, became ever more difficult. In spite of his excellent knowledge of woodcraft, as shown in the almost instinctive way in which he chose his direction, when the only guide was an occasional dim blaze on the trees, Longmire was sometimes obliged to retrace his steps to find our right path. He was quite innocent of the art of cooking, and of any knowledge of our Mexican method of packing our mules, so Wilson and I had this work to do unaided, and the packing, which required to be done over about once in every quarter of an hour after the frequent trials of strength between our plucky little mules and the fallen giants of the forest, tried our patience to the utmost. Wet through during the day by the crossing of streams and fens and contact with the moist undergrowth, we would enjoy to the utmost our evening chat, after the day's work was over and the dishes washed up, as we sat steaming round a huge fire, under the shelter of a huge cedar beneath whose drooping branches covering a space wide enough for a small army the ground seemed never to be directly reached by the rain.

On the fourth day we emerged into the valley of the Nisqually again, where it had been cleared by fire, and at noon the rain, which had been pouring down for we did not know how many days before, clearing away, disclosed to us through the gorge of a precipitous cañon on the north a glimpse of the snowy slopes of Rainier, now apparently not more than fifteen miles distant. Our camp, that night, close to the banks of the stream, was the nearest approach which Longmire had ever made to the mountain, and to us he now surrendered the determination of the route to be followed hereafter.

You will have seen from the sketches shown you this evening, that the general shape of these volcanic peaks is that of a very steep central cone, from which the flanks spread out in long, gentle slopes; these flanks on Mount Rainier have been channeled through by the glaciers which flow down from its sides, into a system of radiating cañons—narrow gorges with almost perpendicular walls from one to two thousand feet in height, while the included spurs have preserved to a certain extent their original broad, gently sloping surface. Could we reach the top of one of these spurs with our animals and baggage, we hoped, from our camp at the foot of the steeper mountain-slope, to be able to make the circuit of the mountain on foot, keeping above the deeper cañon-gorges, near the heads of the glaciers. The task which now lay before us was to find a route practicable for our mules, by which to reach the top of one of these spurs.

On the fifth day we commenced this task, following up the stream on which we were encamped, which was the main head of the Nisqually river, a stream flowing into the southern end of Puget sound. Our course during the morning lay up the bed of this torrent, fording from side to side, and following the stretches of bare shingle, formed of rounded cobble-stones and boulders of granite, which constituted our only available path, for we were hemmed in on either side by steep, precipitous walls. It was a great relief to see once more the clear sky over our head, and we did not grumble at an occasional wetting, when, in our frequent and sometimes dangerous fordings, the water rolled up over the backs of our animals; for in that respect we were not much worse off than we had been in the continual drippings of the forest undergrowth.

In the afternoon we left the main stream and followed the valley of a branch from the east, the clearness of whose waters indicated that they did not come from a glacier, whence we concluded that it would probably lead us to the summit of a spur, between the larger glacier streams. In this, as we afterwards found out, we were not mistaken, but the way proved to be impracticable for our mules. After proceeding a short distance without much difficulty, the valley closed into a narrow gorge, whose steep sides, though supporting a scanty growth of trees and turf, were interrupted by precipitous slopes of broken rock-masses. In our attempt to pass these, our two pack-mules were successively precipitated down amongst the jagged rocks, and though extricated alive, it was only at the expense of great exertions on our part, and very serious cutting and bruising on theirs. Our sympathy for the unfortunate mules was overshadowed by the loss of our remaining barometer, which was fractured in the struggle, and I was convinced more firmly than ever that the combination of the two occupations of mule-driver and carrier of so delicate an instrument as a barometer, which I had attempted in my own person, was not practicable.

After this failure we had barely time to reach the main cañon again, and find a little spot by the side of the stream with a sufficient accumulation of soil to serve as a cushion between our weary bones and the boulders, before night set in upon us. Our poor animals, in default of any other nourishment, were driven to the alternative of chewing the cud of bitter disappointment or the straps of our saddle-bags, and despite the fact that to protect them we used these articles as pillows, their appearance in the morning showed that they had been chosen.

On the following morning, Wilson and I explored the main cañon on foot up to where, a few miles above our camp, our further progress was barred by a wall of ice some 500 feet high, the end of the Nisqually glacier. From a great arched cavern at its base poured out a foaming torrent, some 30 feet in width, with a thundering roar, while an almost constant shower of boulders over its face forbade a near approach. On the left rose a cliff of beautiful white syenitic granite, whose presence explained the seeming anomaly of granite boulders coming from a volcanic peak; for, in the constant trituration of the stream, the fragments of the light gray trachytic lavas of the lower slopes of the peak had apparently been gradually worn away by their harder granite comrades, so that the latter formed the predominating bulk of the shingle of the stream. On our right were precipitous walls, capped by lava-flows, which had covered this pre-existing granite ridge, their lower slopes indeed covered by trees, but so steep withal that we could climb them only by pulling ourselves up from trunk to trunk by our hands.

There evidently was no possibility of getting our animals out of this cañon, so we retraced our steps down the stream to where we had left what we called by courtesy "Longmire's trail," and pushed further eastward into the valley of the Cowlitz river. This was accomplished in two days' travel through a forest country, which differed from that we had already passed, in that it had been devastated by fire. The blackened trunks of the lofty pines, in part fallen across our path in the wildest confusion, like a gigantic game of jackstraws, in part standing ready to fall without a moment's warning, added difficulty and even danger to our journey; and a steady rain, during three days, augmented the more trivial discomforts of travel, and made us almost regret our former forest covering.

On the Cowlitz we found a little band of Indians, housed in rude "lean-to's," made of slabs of the easily-splitting cedar. In spite of their hardiness, as attested by their daily baths in the ice-cold water of the glacier-streams, it was only by the (to them) magnificent reward of a dollar a day that two of their number were induced to guide us to the foot of Mount Rainier by a path known to them in their hunting excursions.

This remnant of a formerly numerous tribe illustrates the condition of many of our northwestern Indians. They consist of only a few families, perhaps not more than a dozen; yet preserve their distinctive language and tribal conditions, live completely isolated, hardly daring to go twenty miles from their home, lest they may encroach upon the territory of some other tribe. As means of communication with other tribes, as well as with the white man, whom this particular tribe rarely see, they use the uncouth Hudson's Bay Company's jargon, or Chinook language, as it is generally called, though it is unworthy the name of a language, consisting only of about 300 words, partly of English, French and

Indian origin, and in part apparently invented by the rough trappers themselves, and partaking of their coarseness.

Under the guidance of our Indians, a comparatively easy though rather wet march of a day and a half brought us finally up on to the crest of the spur east of the head of the Cowlitz river. As we gradually emerged from the forest region into the more open ridge, where grew only isolated clumps of mountain fir and huckleberry bushes, the rain-clouds which had enclosed us for the past three days broke away, and discovered another superb view of the mountain, now quite near us, and yet seeming more lofty and imposing than ever.

The details of its surface were now visible. The very summit was marked by a thin horizontal black line, which we later found to be the rim of the crater. Below this stretched a smooth, unbroken envelope of white, apparently about a third of the way down; then, at irregular distances along its sides, peered out black shoulders of rock, between which were steep broken masses of glacier ice, looking like foaming cascades frozen in the instant of their fall. This lower two-thirds of the peak was the steepest of all, and below it the glaciers, taking the form of ice-rivers, flowed out at more gentle angles, gradually hidden in their ever-deepening beds between the grassy spurs.

Before sunset we had reached the edge of the lower snow-fields, and selected with some care a sheltered spot near a little clump of mountain firs which overhung the Cowlitz glacier, for our permanent camp. We now turned our weary animals loose in a little valley, which formed a naturally enclosed pasture, for in our future explorations over precipitous cliffs and glacier-fields they could be of no further use to us. During our march we had left little notes describing the course we were to pursue on the morrow, carefully fastened under the bark of a tree at each of our camps, to direct Mr. King, who, we expected, would follow us in a short time and bring the much-desired barometer. In anticipation of the arrival of that instrument, we decided to postpone for the present the ascent of the mountain, which otherwise would have been our first task, and in the meantime made a short trip around the flanks of the mountain to examine the glaciers and lavas, and commence the triangulation for our map.

Our first day's trip was among the *nèvé* fields and outlying peaks to the east of the main peak, reaching a high enough point to obtain a comprehensive view of its structure on this side. To the east and north it presents an almost perpendicular face, having been cut down by glacial erosion and the action of snow and frost, so that an ascent from this side would seem almost impossible. An outlying mass of lava, forming a jagged peak with overhanging cliffs on every side which rises some 2,000 or 3,000 feet out of these *nèvé* fields on the east of the peak, at about a half mile from its base, shows by its bedding lines that it originally formed part of the main mass.

Here we came suddenly upon a little band of mountain goats, who, when aware of our presence, fled with most remarkable rapidity up the icy slopes, crossing crevasses and ascending impossible steeps with the greatest ease. We watched them with wonder as they grew smaller and smaller in the distance, and finally disappeared among the ice-cascades of the steep mountain-side. This rare animal, the *Azama montana* of science, which is found only on the slopes of these snowy peaks, and there in limited numbers, is a very distinct animal from the big-horn or Rocky Mountain sheep. It is a low, heavy-built animal, rather larger than a good-sized ram, snow-white in color, having a thick fur of mixed hair and wool, a long white beard, and two little, black, curved horns like those of the chamois. It passes its day among the snows, only coming down at early dawn to browse upon the fresh green grass along their lower edge. Our Indians, taking advantage of this habit, after concealing themselves for two nights near one of their favorite grazing-grounds, succeeded in killing one, which they sold to us, and which was a most timely addition to our scanty larder, saving us, as it proved in the end, from possible starvation.

From our permanent camp we made a trip to the northern flanks of the mountain beyond the White river, carrying our blankets, provisions and instruments on our backs. The first valley to the north of the spur by which we had reached the summit we found to be that of a tributary of the Cowlitz river, rejoicing in the euphonious name of Och-hanna-pi-cosh. It heads in an amphitheatre-shaped valley, characteristic of the slopes of Rainier, but of unusually grand proportions, reminding one of the famous *cirques* of the Pyrenees. The walls of this amphitheatre, semi-circular in form, are composed of a thickness of about 2,000 feet of light-gray trachytic lava-beds, capped by as many hundred feet of glacier-ice, which stand as straight and regular as if built of masonry. Over the face of this perpendicular cliff pour a hundred tiny streams of water from under the ice-cap, looking, from below, like so many silver threads, which, in their long fall, are dissipated into a fine mist before they reach the grassy carpet of the valley below. At the lo.wer end of the valley, these waters, united into a foaming brook, make a bold leap over a second cliff above the forest-clad valley beneath, and, striking obliquely the face of a rocky wall, into which they have worn a deep pot-hole some ten feet in diameter, rebound upwards into the air at an angle, forming a most beautiful natural fountain, from which the unpronounceable Indian name of the stream, which signifies "spouting water," is derived.

A high, rocky ridge, probably as much as 7,000 feet above sea-level, which connects Mt. Rainier with the crest of the Cascade mountains, some ten or fifteen miles further east, forms the divide between this stream and the White river, one of the largest, if not *the* largest stream which flows into Puget sound. An immense system of glaciers, some seven or eight in number, which flow down from the steep northeastern slopes of the peak, unite to form this stream, whose name evidently originates from the milky nature of its waters, a character common to glacier-streams. These larger glaciers present all the peculiar phenomena of the glaciers of the Alps, which have been so well described by Agassiz and Tyndall. On the largest, which is about three miles wide where crossed by us, are several medial moraines—great ridges of rock-fragments and loose gravel,—while little brooks of pure water course over its surface and disappear in the midst of their course down round well-like holes called, in Swiss glacier-parlance, *moulins*.

We camped on the north side of these glaciers, and climbed a high outlying peak from whose summit we could see, thousands of feet below us on the north side, another great glacier, and on its surface a deep blue lake, which we estimated to be about an eighth of a mile in diameter. The stream issuing from this glacier is either another branch of the White river, or a tributary of the Puyallup river, which flows from the northwestern slopes of Rainier into Puget sound. On the borders of the White River basin we found, under the lavas, outcrops of porphyritic rocks, which, together with the granite seen at the head of the Nisqually river, proved that eruptive rocks had been poured out in this region in geological periods long before the formation of the present volcano.

On our return from the White river trip we spent some days in measuring a base-line for our triangulation, and in exploring the southern slopes of the mountain, at the head of the Cowlitz and Nisqually rivers. One morning Longmire, who had thus far remained to take care of camp—for he was soon tired of climbing with us—announced his intention of returning home, as he thought the weather looked threatening. Our remaining Indian—one had left immediately upon receiving his pay for the mountain goat—whom we had christened Muck-a-muck, or "hungry," from his inordinate capacity for eating, no sooner heard of this than he decided that he must go, too. He said that we had now had ten days of pleasant weather, and at this season might soon expect a storm—"hiyou snow"—which, should it come, would, in a short time, bury us neck-deep, and then we could not get away. No persuasion or hopes of gain would induce them to stay, so we bade them farewell, consoling ourselves with the thought that we had now only two mouths to feed instead of four.

After their departure we watched the weather anxiously, for they had told us that if the wind changed to the southwest we would surely have a storm. Sure enough, the next morning the wind had veered round to the dreaded direction. From our elevated position—for we were on a level with the highest summits of the Cascade mountains—we could see the valleys below us gradually fill with heavy storm-clouds, which rolled up angrily against the base of the mountain, and finally enveloped us. It was not a very pleasant outlook, for, even with our scant allowance of a cup of flour and two spoonfuls of coffee per day to each man, our provisions could only last nine days longer, and yet it would not do to go back without having ascended the mountain, even if no barometers arrived with which to measure its height. Four days we spent thus, eating, sleeping and listening to the frequent thunders of the avalanches over our heads, as it were, in the hidden mountain, for we could not venture far from camp for fear of getting lost in the clouds. Fortunately the snow did not fall as deeply as Muck-a-muck had predicted, but it was very cold, and the springs, on which we depended for water, only thawed out for a few hours during the day. Now and again the clouds would break for a few moments, and we would catch a glimpse over the immense sea of white which hid everything below. Shut out thus completely from the rest of the world, our only companions were the white summits of the great volcanoes to the south, which reared above the clouds. On Mt. Adams, the nearest peak, we frequently observed the beautiful phenomenon of a cast of its shape made in the cloud-mass, as the white cloak, which usually hung round its summit, would occasionally lift straight up into the clear air above, like a snowy helmet, keeping perfectly the mould of its form.

At length the wind changed to the northward, the sun came out clear and bright, and we made hasty preparations for our ascent of the mountain without further delay. We baked our three cups of flour each for three days' provision, put hobbles on the old mare that she and her charge might not be tempted to wander away in our absence, rolled up the necessaries of life in our blankets, and climbed down the adjoining precipice on to the Cowlitz glacier, which ran about 1,500 feet below our camp. This pack-carrying was the most trying work we had to do, being that to which we were least accustomed, and we found a roll of blankets three feet long by a foot or more in diameter, weighing 30 or 40 pounds and tied to our backs by a bit of clothes-line, an extremely awkward burden in our hand-and-foot descending the steep precipices which border the glaciers. We felt the strain on our loins very seriously in our climb of the following day. The Indians, who are more accustomed to carrying burdens, manage it by passing a strap across the forehead, so that the principal strain comes upon their necks, which have thus acquired a strength like that of a bull.

We selected for our starting-point a little grassy hollow on the edge of the snow, near the twisted trunk of a dead mountain pine (*Pinus flexilis*), the highest bit of fire-wood we could find, and spent the afternoon studying the slopes of the mountain from neighboring eminences, and estimating the time we should require for the climb, knowing we must get back by day-light, or run the risk of freezing to death on the summit. We decided to start at three in the morning, but Wilson was prevented from sleeping during the early part of the night by neuralgia, and when the time came I had not the heart to wake him out of his sound slumber.

At 4 A. M., however, of October 17th, we finally started for the summit of the mountain. The moon was in its last quarter and shed a pale light over the rocks and snow, so that from our observations of the previous afternoon we had no difficulty in following the route then laid out. Our course at first lay over alternate cliffs of loose, broken lava, and broad ice-fields. The ice-travelling was much the easier, but in the uncertain light of the moon we were afraid of falling into crevasses, and therefore chose rather the more difficult rocks. On we toiled, not fast, but at a steady, unvarying gait, for a couple of hours or more, when the first gray light of morning began to appear over the summits of the Cascade mountains; soon a pale, rosy tinge suffused the tops of Adams and Hood—we were too near to see the summit of Rainier—and now, ere long, the sun burst forth at its full glory. As the rays of light shot upward to the mountain-top, they lighted up the immense masses of ice and snow which overhung us, and gave to them the beautiful transparent blue tinge which may be seen in the interior of the crevasses of a glacier. We reached the foot of the steep rocky spur which we had chosen for the ascent, at the end of the third hour—exactly the time we had allotted—and congratulated ourselves on the accuracy of our calculations. We now had two hours of actual hand-and-foot climbing up a narrow, jagged ridge of huge loose blocks of lava, occasionally meeting a perpendicular cliff, round which we had to climb, clinging as best we could to the little inequalities and cracks in the rock. These spots were often a little trying to one's nerves, as the rock was crumbly, and the ridge on which we stood fell off steeply on either side, while the smooth ice of the glaciers at its foot sloped down at a sufficiently steep angle to send anything which should fall upon it with the swiftness of an arrow into the crevasses below, as we had frequent proof in the occasional fragments of rock which were dislodged from beneath our feet.

These glaciers came down from the foot of the ice-cascades already mentioned, which towered above us on either side, presenting a surface bristling with sharp, icy pinnacles, over which it were impossible for any living thing to climb. At the head of our ridge a great black mass of rock projected from the icy envelope which clothed the mountains, presenting to us an overhanging precipice nearly a thousand feet in height. It was composed of stratified layers of lava and breccia, or hardened volcanic mud. The latter being more yielding, had crumbled away, so as to present a series of shelves within the face of the cliff. At nine o'clock we reached its foot, and stopping for a few moments to finish the breakfast we had done but scanty justice to before, we then crawled cautiously along one of these shelves, about ten feet in width, clinging closely to its upper wall, while the pebbles and sand from under our feet rolled constantly over the precipice below, falling to an unknown depth, and thus we reached the apex of a re-entering angle of the mountain, where the rock and ice-mass came in contact. On our left hand towered pinnacles of ice like huge inverted icicles, while over us on the right hung the cliffs of black and red lava, masses of which were constantly falling, but beyond us, as we were protected by the projecting shelf of rock. At the junction of the ice and rock, however, was a steep, smooth, winding passage, wide enough to admit a man's body, which had been made by the melting of the ice in contact with the rock. Here I found hanging a heavy rope, the first relic we had met of the Stevens party. Crawling cautiously over the slope of gravelly ice which extended out from the foot of this passage, I seized the rope and gave it a strong shake, to test the secureness of its fastening. The test was too much, and it came down upon my head. Fortunately, I had a firm footing; so coiling it about my waist for further use, I loosed the hammer from my belt and advanced to the foot of the chimney-like passage, to cut notches or steps in the ice, by which we might ascend. As, balancing myself carefully on one foot, which rested on a stone frozen in the ice, I leaned forward, the edge of my pack, made up (like that of the French soldier) of knapsack and roll of overcoat, struck the overhanging rock, and nearly threw me off my balance, so, straightening up, I let it slip down from my shoulders; as it reached the elbows, thus pinning them together, a sort of nervous shudder came over me, and dropping it hastily without making any provision to catch it, it struck edgewise on the ice, and commenced rolling slowly down towards the brink of the precipice a few yards below us. We watched it go, both unable to move, hoping every minute it would turn on its flat side, but it kept steadily rolling, and soon disappeared over the brink, dropping quietly into space below, and sending up no sound to tell when it had reached bottom. This made us conscious of the danger of our position; moreover, the loss at that time was quite serious, for it contained our little stock of brandy, coffee and firewood, prepared for warming ourselves on the summit, and an overcoat that could not be replaced. We had, however, no time for regret. I cut my steps (holes in the ice deep enough to insert the toes of one foot at a time) and proceeded upwards, reaching in about 40 feet another shelf, where I stopped and drew up Wilson's instrument, he following. Then on again, the chimney becoming constantly steeper, so that at last I could scarcely lean my body back far enough to chop the ice in front of me, for fear of toppling over backward, for the smooth surface offered nothing to hold on to; in the windings of the chimney I could never see far above me, and when I had nearly reached the top, I perceived, to my horror, imbedded in a projecting mass of ice directly overhead, a huge boulder weighing 200 or 300 pounds, now about two-thirds melted out. All the way up there had been a constant rain of small pebbles on my head, for the day was at its warmest point, but as I saw this boulder I hesitated an instant, knowing that its fall meant inevitable destruction. However, to return was equally as dangerous as to proceed, so I continued on. Fortunately it did not fall while we were in the chimney, but when we returned from the summit we looked anxiously for it, and it was no longer there.

Seating myself, somewhat insecurely, on a little rounded ridge of ice at the head of the chimney, I uncoiled the rope, and hauled up the instruments. Wilson followed, holding on by it, though I had sufficient confidence in his steadiness not to tell him how slight a strain would pull me from my seat.

From here, after a short scramble over steep rough hummocks of ice, we reached the upper slope of the mountain. Here a new barrier presented itself to our progress in an immense crevasse, some twenty feet wide, and of unknown depth, which stretched obliquely across our path, extending a mile or more nearly up to one of the secondary summits to the west of the peak at which we were aiming. For a moment this seemed impassable, but climbing a little ridge of glassy blue ice about twenty feet high, we discovered on its further side a a natural snow-bridge across the crevasse, and by using our rope after the most approved Alpine fashion, we succeeded in crossing it in safety. Beyond this we met with no crevasses too wide to jump, and now had a comparatively easy climb of a couple of hours to the summit, over an ice-slope standing at an angle of near 30°; steep enough to be dangerous, but whose surface, somewhat softened by the heat of the midday sun, gave us a tolerably secure footing. At one o'clock we had reached the summit of Rainier, which we estimated, from the time it had taken (nine hours), to be about 9,000 feet above our camp at the snow-line.

We stood upon the edge of a bowl-shaped crater of almost perfect circular shape, forming the eastern edge and highest point of the mountain, its interior filled to within 30 or 40 feet of the rim with ice and snow, while on its outer slopes the blackened lava, of which it was composed, was laid bare for a hundred feet or more below its summit. This was the delicate black line, which we had sometimes been able to distinguish from below, as forming the summit. Adjoining this on the west was another semi-circular rim of rock, peering out of the snow, the remains of a former crater, in the interior of which this more recent one had built itself up. It was strange to see even these comparatively small patches of rock free from the universal covering of ice and snow ; the explanation first presented to the mind was their exposed position, and the tremendous force of the wind, which seemed almost sufficient to blow away the very rocks. A second was soon seen in the evidences of internal heat at no great depth below the surface, shown by countless jets of steam and gas, in size from a pin-head to an inch in diameter, issuing around the interior rim of the crater. Near these jets the hard rock is changed into a red clayey mass, and in front of them, by the condensation of the steam, ice-caverns have been formed, some of sufficient size to admit several persons. In one of these we took refuge for a few moments to warm ourselves and thaw our fingers, two of mine being slightly frost-bitten; for although the thermometer was only at the freezing-point, the violence of the wind rapidly abstracted from our bodies the animal heat, upon which the exertions of the climb had already made serious inroads ; and in the ragged condition of my own clothes, I was constantly impressed with the seriousness of the loss in letting my over-coat drop over the precipice.

From our summit we could see the two other peaks, only a few hundred feet lower than ourselves, the one to the southwest, and the other to the northwest, one to two miles distant, and separated by the heads of a deep valley filled by *nèvé* ice which sloped rapidly to the westward between the two peaks. It was evident that this valley was the interior of a still older and larger crater, of the walls of which these two peaks are the remnants. The crater upon which we stood had been built up as an interior cone, entirely within the wall of this older crater, and the outstanding pinnacle of rock on the east, which we had observed on our first day's climb on the glaciers, must be the only remnant left of the east side of this outer cone ; over a third of the mountain's mass has been carried away, and that largely by the agency of glacier-ice.

From the northeastern rim of the crater we could look down an unbroken slope of nearly 10,000 feet to the head of the White river, the upper half or two-thirds of which was so steep that one had the feeling of looking over a perpendicular wall. The systems of glaciers, and the streams which flowed from them, lay spread out as on a map at our feet; radiating out in every direction from the central mass, they all with one accord curved to the westward to send their water down towards Puget sound or the lower Columbia river. Looking to the more distant country, the whole stretch of Puget sound, seeming like a pretty little lake embowered in green, could be seen in the northwest, beyond which the Olympus mountains extended out into the Pacific ocean. The Cascade mountains, lying dwarfed at our feet, could be traced northward into British Columbia, and southward into Oregon, while above them, at comparatively regular intervals, rose the ghost-like forms of our companion volcanoes. To the eastward the eye ranged for hundreds of miles over chain on chain of mountain-ridges, which gradually disappeared in the dim blue distance.

Two hours was all the time we dared give to the summit, for both wind and cold were constantly increasing. Wilson had attempted to set up his theodolite on a little knob of ice that projected some 50 feet above the highest point of the crater's rim, but an unusually strong gust of wind had taken both the instrument and him off their feet, and accepting the inevitable he allowed himself to slide gently down its sides, and gave up the attempt. We wished to visit the other two peaks, for they cut off our view to the westward, and the triangulation on that side would require some time, but it was now out of our power.

At three o'clock we commenced the descent. This was in some respects more dangerous than the ascent, for my creepers (a rude spiked sole we had had made for ice-walking by a blacksmith in Olympia) had gone over the precipice with my pack; every step down the first ice-slope had to be taken with the greatest caution, bracing the foot by the spiked point of a tripod leg, lest a single slip might send me whirling into the crevasses below. Here Wilson took the lead, that, should I slip, his firmer footing might steady me. Our descent of the chimney, which would have been almost impossible otherwise, for our steps were largely melted out, was rendered comparatively easy by the rope, which we fastened firmly in a rock at its head, and left hanging for any future explorer who might wish to make the ascent.

It was just sunset when we reached the foot of the steep slope, and we had an opportunity of observing again that strange shadow phenomenon which Mr. King has noted in his description of Shasta. As the sun sank beneath the horizon its light gradually disappeared from the country below, and only the upper part of the mountain was lighted up; during nearly half an hour the dark conical shadow of this mass traveled slowly eastward over the country, until, reaching the horizon, it rose up against the sky like a second gigantic mountain. Darkness came upon us apace; in the dim starlight every rock seemed a hole, and every hole a rock; footsore and weary, we stumbled along for three hours more, before reaching our camp, and it was a very fortunate chance that guided us to it, for there was nothing to mark the spot where we had left our blankets. Seventeen hours had been spent in the climb, but hunger rather than fatigue was the more prominent feeling with us during the following days.

On our return to the main camp, we found everything safe, though our eyes detected fresh horse-tracks in the sod, which proved to have been the Indians, who had returned to make us a visit when the storm was over. We now turned our faces towards civilization, and as our stock of provisions was reduced to three days' supply, we were forced to select a quicker route than that by which we had come. So, instead of going west, we determined to strike eastward across the Cascade mountains, having learned from the Indians that there was a trail in that direction, by following which we might reach Fort Simcöe, the residence of a Government Indian Agent.

Making everything ready the night before, we got an early start, and marched with such eagerness that night overtook us on a steep mountain-side, where, for fear of losing the trail we could no longer see, we were obliged to camp without water. By the second night we had reached the summit, or divide, of the Cascade mountains, and it was none too soon, for the storm-clouds were following close behind us. All night long the winds raged fiercely about us, and the following day we descended the eastern slope in a drenching rain, which was snow in the region we had just left—the first of the season on that side of the mountains. Our difficulties were not quite over, for it took one day longer than we had calculated to find the Indian reservation, and a very hungry one that was. The good people there looked rather askance at the two ragged, dirty-looking individuals who presented themselves at the door of their comfortable dwelling one afternoon, claiming to be United States explorers who had just made the ascent of Rainier. They were convinced after a while of the truth of our story, and the ravenousness with which we devoured two solid meals within as many hours left no further doubt in their minds. Two days more of rapid traveling brought us to the town of Dalles, on the Columbia, where we were received with rejoicing by our companions, who had given us up as lost, having heard nothing from us since we started into the forest, exactly a month before. My appetite continued to be ravenous for a month afterwards, though I gained eight pounds in the first twenty-four hours after my arrival at the Dalles, upon the far from luxurious fare of a frontier hotel.